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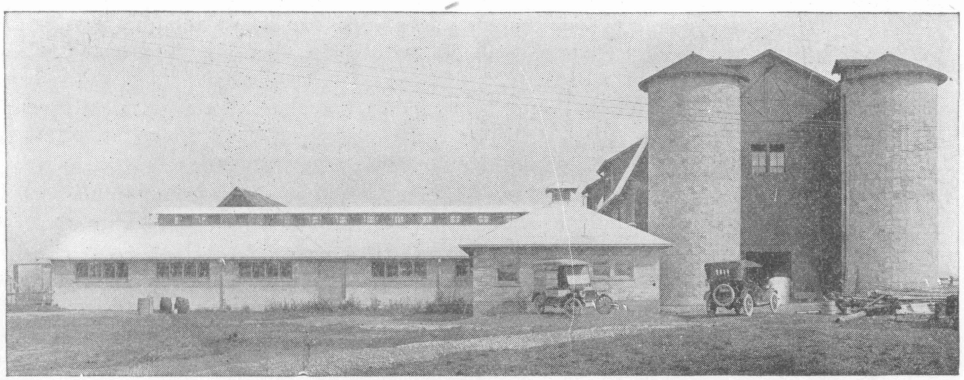
SILO CONSTRUCTION



An Attractive Farm Scene with Silos and Dairy Barn.

T. O. WALTON

Acting Director, College Station, Texas.

SILO CONSTRUCTION.

INTRODUCTION.

The farmers of Texas, who are getting the best results from stock farms, are those who have so planned their crop-acreage and rotation as to provide at all times, an ample supply of the proper sorts of feed for the class of stock which they are raising. Silage makes a satisfactory foundation ration for all cattle. Silage crops of some kind may be easily and profitably grown on all tillable Texas soils. A large variety of crops are adapted to silage purposes. A sufficient amount of forage to furnish silage for the stock can almost invariably be grown on the average farm regardless of drought or excessive moisture. The silo, therefore, has been spoken of as "insurance against drought."

The use of silos leads to soil improvement, as they permit the return of all crop-residues to the soil in the form of barnyard manure. They can be used to preserve feed that might otherwise be spoiled by drought or by excessive rain, Less labor is required to produce a silage crop than a cotton crop and less labor is required to feed it to stock, than to harvest a cotton crop.

For these and other reasons, the Extension Service is encouraging the building of more silos in Texas. It is recognized that different types of silos are suitable and practicable on different farms and in different communities. The Extension Service does not advocate any particular type of silo for every section, but desires to give definite dependable information in regard to the fundamentals for silo construction and the use of silage.

With this in view, employees of the Extension Service are encouraging farmers in every possible way to secure, erect and fill silos, and feed silage to different classes of animals. Specific inquiries will be answered by mail.

This bulletin contains information regarding some of the fundamentals of silo construction and a more elaborate discussion of how to construct some of the types of silos, commonly used in Texas.

Bulletin B-39, "The Underground Silo," published by the Extension Service last year treats of the underground silo in Texas, and a copy may be had by writing to the Extension Service, A. and M. College of Texas.

Complete bulletins have already been published by the United States Department of Agriculture on homemade silos, and on silage feeding, so that it is not deemed necessary to duplicate such instructions in this bulletin. The bulletins mentioned, may be had free by addressing the United States Department of Agriculture, Washington, D. C., and requesting the bulletins by number as follows: No. 578, "The Making and Feeding. of Silage;" No. 755, "Homemade Silos;" which includes instructions for erecting concrete silos.

T. O. WALTON, Acting Director.

SILO CONSTRUCTION

By C. M. EVANS.

Every silo must incorporate certain essential features in order to prove successful, and in addition to these, there are other desirable features which add to its value. The absolute essentials are those which are necessary to insure the preservation of the silage. Both the essential and desirable features are herein outlined.

ESSENTIAL FEATURES.

Imperviousness of Walls: The fundamental principles for the preservation of silage are the retention of moisture within the silage and the exclusion of air. For this reason the silo must be moisture-proof; moisture must be prevented from passing out, and air from passing in.

Strength of Walls. The walls of the silo must be sufficiently strong to resist the pressure of the silage, which acts outward in all directions as the silage settles. The friction of the silage on the walls and the weight of the material, produce a crushing force which is greatest near the bottom of the silo.

Smoothness of Walls: To permit the silage to settle freely and to prevent the formation of airpockets, the walls should be smooth on the inside and have neither shoulder nor offsets. Air pockets result in more or less spoiled silage.

DESIRABLE FEATURES.

Durability: Outside of the absolute essentials of silo construction, the most desirable feature to be secured in a silo is durability. This depends, first, upon the silo's strength, and second, upon the durability of the material used in its construction. To be durable, any material must resist the action of the weather, the constant wetting and drying, freezing and thawing in the winter season and any disintegrating action which may be due to the silage itself. Some materials will disintegrate with age and other materials suffer from rapid decay when subject to the warm moist condition which exists in the silo.

Cost and Repair: A silo should require the least possible expenditure in the way of labor and material for its construction and upkeep. A silo which must be adjusted for shrinkage and expansion is of less value than one which does not need such attention. Often this work is neglected, and loss results. Some silos must be repainted frequently to be attractive; this means added expense. All parts should be equally durable and lasting. The replacement of parts which are short lived and the substitution of new pieces for those which have either become decayed, faulty, or for any other reason, add materially, in many cases, to the cost of maintaining a silo.

Wind Resistance: A silo should be so constructed as to resist high winds, which may occur during the time it must remain empty. Insurance companies regulate their rates of storm risks on the various types of silos by their relative merits for wind resistance.

Convenience: A silo should possess conveniences for filling, having the doors so arranged that the silage may be easily removed from day to day, when desirable, and so constructed that they can be put into place and removed with the least effort. They should permit easy access to the silo and allow the removal of the silage with the least possible amount of labor.

Portability: There are instances where tenants or others desire a silo that may be used in one place for a time and then moved to a new location. Under such circumstances this feature should be given due consideration.

Fire Proof Construction: It adds materially to the value for any building to be made of fire proof material. The importance of this feature is realized when the large annual loss by fire is taken into consideration. This is of less importance when the silo is not located near a barn or other buildings.

Appearance: All farm buildings should have a good appearance. This feature adds to the attractiveness and the value of the farm. Other things being equal, the construction of a permanent silo, having a neat appearance, is most desirable.

Simplicity of Construction: It is sometime advisable to select a silo which can be constructed without using skilled labor, or special tools, or to purchase one ready for erection without the aid of skilled labor.

Cost: One of the important features to be considered in the selection of a silo is the cost. The silo which will afford storage for silage at the least cost for construction and upkeep per ton, is the silo to build, other points being equal.

LOCATION AND SIZE OF SILO.

It is now customary to locate silos outside of the barn. The majority are so constructed that they do not need such protection, and it is not economical to place them in a building where they will occupy space that may be put to other use.

When located outside of the building and connected by a passage provided with doors, the objectionable odor of the silage may be kept out of the building and the silage may be delivered to the cutter more conveniently. A very common arrangement is to select such a location as will permit the passageway from the silo to the barn to be a continuation of the feedway in the barn.

The usual silo to-day is 30 feet or more in depth. A larger percentage of moldy and otherwise inferior silage is found nearer the top than at the center or near the bottom, proving that a certain weight is necessary to compress the silage and exclude the air, so as to insure perfect preservation. The quality improves as the depth increases, due to the weight from above. At present good practice seems to favor a depth of at least 30 feet. Some limitation in height may become necessary in case of light construction, on account of the wind or of the necessity of strength in the walls to resist crumbling. In the construction of masonry silos, a greater depth than the average is advisable, many being built as high as 50 feet. However, the greater the height, the greater the power necessary to operate the cutter and blower in filling, so for this reason, it is not often advisable to build them more than 40 feet high. Capacity may be increased by going from three to six feet in the ground.

The capacity of a silo varies as the square of the diameter, while the wall surface varies directly as the diameter. This means that in so far as capacity is concerned, the silo should be of as large diameter as possible. But there are other limiting factors that must be taken into consideration. Tall silos hold more in comparison to diameter on account of greater pressure. In silos of wide diameter it is necessary to handle the silage twice to get it out and when silage is left exposed to the air for a short time,—say more than one day,—it spoils.

Enough must be removed daily to permit it to keep fresh. In well settled silage the spoilage does not penetrate more than an inch per day and if one and one-half to two inches are fed from the surface daily, the remainder will keep fresh. In warm weather the spoiling will take place much more rapidly than in cold weather, making it necessary to remove from the surface a greater depth each day in order to keep it fresh. After it has been placed in the silo there is more or less settling, the amount of which will depend on the condition of the silage and the amount of tramping given when the silo is filled. Under average conditions the settling will amount to about one-sixth or one-fifth of the total depth.

Table No. 1 gives the capacity of various sizes of round silos. Table No. 2 in-

dicates the size needed to furnish herds of different numbers the daily requirements. The table of capacities is based upon the observation of Professor F. H. King, of Wisconsin, and assumes that the silage is made of well matured corn and that the silo has been filled and allowed to settle for two days; and that after the silo has been filled and allowed to settle for two days, it has been refilled to the top. The amount which should be fed daily is based upon an average weight of forty pounds per cubic foot. The weight will vary with the kind of crop, grain content and moisture content. Sorghum is lighter than good corn and feterita is lighter than sorghum. In studying this table it will be seen that a silo 16 feet in diameter and thirty feet deep will hold 119 tons of silage, while if its depth be forty feet it will hold 180 tons or more than one-half more. Thus the economy of silage in the depth of the silo is observed.

TABLE NO. 1. CAPACITY OF ROUND SILOS IN TONS.

For ordinary silage, somewhat dry, take two-thirds or three-fourths of amounts stated.

Inside height of silo.	DIAMETER OF SILO.							
	8-ft.	10-ft.	12-ft.	14-ft.	16-ft.	18-ft.	20-ft.	22-ft.
20 ft.	17	26	38	51	67			
21 ft.	18	28	41	55	72			
22 ft.	19	30	43	59	77			
23 ft.	20	32	46	63	81	103		
24 ft.	22	34	49	67	86	110		
25 ft.	23	36	52	71	91	116	143	
26 ft.	24	38	55	75	97	123	152	
27 ft.	25	40	58	79	102	130	160	
28 ft.	27	42	61	83	109	137	169	205
29 ft.	28	44	64	87	114	144	178	216
30 ft.	30	47	67	91	119	151	187	226
31 ft.	31	49	70	96	125	158	196	237
32 ft.	33	51	74	100	131	166	205	248
33 ft.	35	53	77	105	137	174	215	260
34 ft.	36	56	80	109	143	181	224	271
35 ft.	37	58	84	114	149	189	234	282
36 ft.	39	61	87	118	155	196	243	293
38 ft.	41	66	94	128	167	212	262	316
40 ft.	45	70	101	138	180	228	282	340
45 ft.				165	215	269	330	399
50 ft.						310	382	462

Table giving the capacity of round silos in tons of silage.

TABLE NO. 2.

No. Cows.	Tons Silage for 6 months.	Diameter of Silo.	Height of Silo.	Acreage to Fill 10 Tons per Acre.	Acreage to Fill 6 Tons per Acre.
12	37¾	10	26	3	6¼
15	40½	10	28	4	6¾
20	54	12	27	5½	9
25	67½	14	25	7	11
30	81	14	29	8	13½
35	94½	16	26	10	16
40	108	16	29	11	18
45	121½	18	27	12	20
50	135	18	29	14	22½
75	202	20	34	20	34
100	270	20	40	27	45

Table showing requirements for different herds.

FOUNDATION.

Any building should rest upon a foundation broad enough to prevent appreciable settling and deep enough to rest on soil that is never disturbed by frost. In case of a masonry silo the foundation may be advantageously a continuation of the wall. While a very cheap addition to the capacity of the silo is secured by putting the floor and footing several feet below the surface, yet beyond a certain depth the difficulty in removing the silage is so great as to more than balance the economy of securing additional space in this way. Three or four feet up to the first door is not considered objectionable. There should not be a shoulder or offset in the wall between the foundation and silo wall, as this is sure to be the cause of spoiled silage due to improper settling of silage.

FLOOR.

Where the silo rests upon dry clay or non-porous soil and where the foundation is deep enough to prevent undermining by rats, the floor may be omitted. In general, however, a floor is quite desirable. A silo floor need not be expensive as the weight of the silage will not be so very great, if distributed evenly over the surface, and will be just as firmly supported as if the floor were not used. A masonry floor, four to six inches in thickness will be satisfactory. If properly mixed sand and gravel can be obtained, a good cement floor can be constructed of one part of cement to five parts of sand and gravel. The concrete should be thoroughly packed and troweled.

ROOF.

It is frequently believed that the greatest disadvantage of a roof lies in the danger of the silage freezing and for this reason many silos have been erected in Texas without roofs. The roof is important for other reasons, however. Without a roof the silage is mixed with snow or wet down with rain. A silo without a roof becomes a catch-place for dust or anything carried in the wind and a favorite feeding ground for pigeons and birds of the neighborhood. A roof frequently compensates for its cost by affording a more pleasant place to feed from in bad weather. It also adds to the appearance of the silo. A door for filling—large enough to admit the carrier or elevator from the silage cutter—should be placed in the roof. This may be either a simple trap door or a dormer window with glass. Some light should be admitted to the silo, otherwise it will be necessary to use a lantern when removing the silage. A roof on a wooden silo makes it more substantial. Roofs are not absolutely essential, in Texas. Where there is no roof, the silo may be filled above the top sufficiently to take care of most of the settling by using a string of paling fence around the top. The pitch of the silo roof may vary from one-fourth to one-half. Steep roofs permit the silo to be filled above the top of the wall so as to be nearly full after settling. The flat roof does not permit the silage to be elevated to a point during filling. The framing for a silo roof is shown on page No. 11. Prepared roofing is regarded as the best covering and will make a roof more nearly air-tight which is very satisfactory when a good quality is used. It also has the advantage of being easily put in place. Roofing should be cut in three cornered pieces, so that the length will extend from the top of the cone to the eaves. In this way the material will be used economically and an airtight roof will be had, retaining the heat. Frame boards do not make a good roof; if they are used, the cracks should be carefully covered with battens.

ANCHORING.

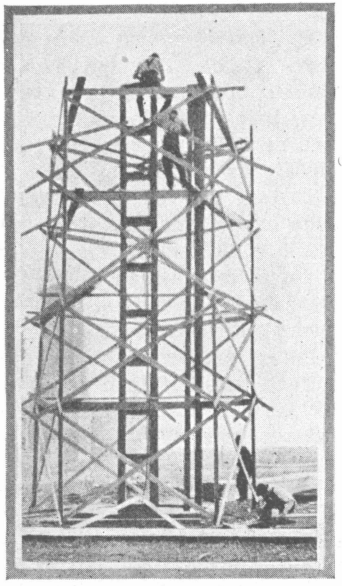
Silos of light construction, if exposed to the force of high winds, should be securely anchored. Such silos should be fastened by anchor bolts extending into the foundation and also by guy wires extending into a deadman or anchor post in the yard, placed at some distance from the silo, insuring the effectiveness of the guy wires. Many times advantage can be taken of the opportunity to fasten the silo to adjoining buildings in so far as the location will permit.

DRAINAGE.

Drainage is of great importance and should receive more consideration than is usually given it in the construction of farm buildings and especially in masonry silos. Any soil will support a greater load when dry than when wet. This is especially true of clay. Unless the silo is to be located on high, well drained land, drain tile should be used to remove the ground water. These tile will carry off all excess moisture and prevent the ground adjacent to the silo from becoming muddy, especially during and immediately after heavy rains.

DIRECTIONS FOR ERECTING WOODEN STAVE SILOS.

The erection of wooden stave silos is a much simpler proposition than the uninitiated might suppose. The actual amount of time and labor necessary to complete this operation, of course, depends upon local conditions and the size of the silo. From one to two days should be sufficient time to cover the setting up of any size silo above the foundation and exclusive of the roof. In the case of medium, to small sized silos, one day will generally be found sufficient and the largest should not require more than two days, where the labor and proper material for building the scaffold, are available. Four men will be necessary in erecting to the best advantage. It does not require an expert and most wood stave silos are erected by farm labor without even the aid of a carpenter.



No. 2. Shows Construction of Scaffolding.

THE SCAFFOLD.

Material for a scaffold for 8, 10 or 12 ft. silos, 5 bents and 3 stages.

5 pieces of 2x4, the height of the silo, either 1 or 2 pieces for uprights.

10 pieces of 2x6-12 of 2x8-12 free from knots if possible for walking boards.

15 pieces 1x4-10 sheeting boards for horizontal ties to lay walking boards on.

30 pieces 1x4-12 sheeting boards for diagonal braces.

For larger diameters add bents as needed.

For greater heights add stages as needed.

ERECTING SCAFFOLD.

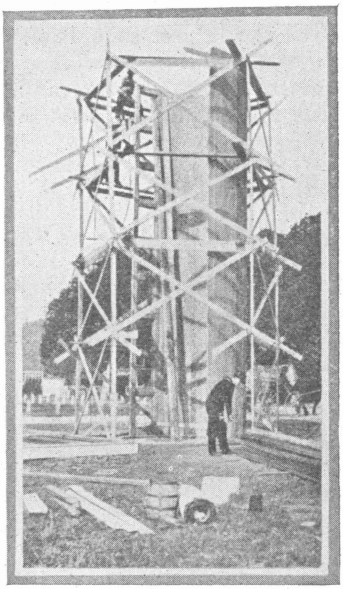
Set up 2x4 uprights at a point 3 feet outside of silo foundation and 10 feet apart Set these uprights plumb. Put up 2 diagonal braces between each pair of 2x4 uprights as high as one can reach from the ground, using one 8 D. nail in each end of braces. Seven feet from the ground put on a 1x4 horizontal tie between each two uprights, using three 8 D nails in each end. Keep these horizontal tie boards as level around the silo as possible. Now put up walking boards inside the uprights—one between each pair of uprights—the ends of walking boards resting on the horizontal tie boards and against the uprights. Climb upon walking boards and proceed with stages above just as with the one built from the ground. Each row of horizontal ties should be 7 feet above the ties below.

SETTING UP DOOR FRAME.

Take off one pair of diagonal braces on scaffold opposite place where door frame is to set. Carry the door frame through this opening with the top end first. Fasten rope to top bar of door frame and with the aid of two men on the running board of scaffold, or with pulley on upright of scaffold, lift frame upright and set tongue and groove of frame staves on line traced on foundation. Set door frame on end marked "bottom".

PLUMBING AND BRACING.

Use true level or plumb line on frame, being sure that the frame is plumb sideways, in, and out. Then brace the frame solidly to the barn if possible; if not, to scaffold uprights. The frame may have a slight bend in it. Look down the frame from the top and if the frame is not straight after being plumbed, brace frame at bend and pull the spring out of the frame, bracing solidly to hold the frame true. It is very difficult to erect a good silo when the door frame is not plumb. Braces should be nailed to a 2x4 on frame and be left intact until the hoops are tightened.



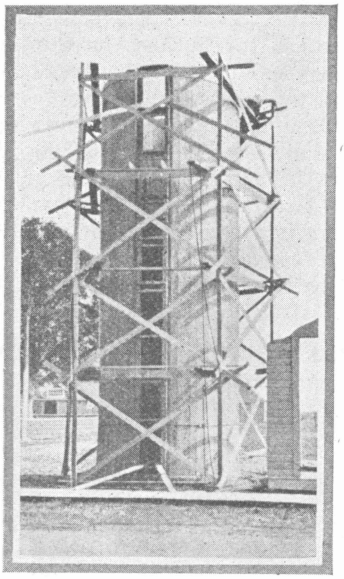
No. 3. The Putting on of Staves.

SETTING UP STAVES.

All wooden silo staves should be beveled. When setting up staves 24 feet long or longer, use one man at the top, one at the middle and one man at bottom of stave, each man to tack on a row of barrel staves. When setting up shorter staves, one man at the top and one at the bottom will be sufficient. Use barrel staves from sugar barrels, cracker or salt barrels. Split the wider barrel staves. Fasten first barrel stave to door frame at right angles, using shingle nails, then nail to each silo stave as it is being set in place. Pull silo staves as tightly as possible by hand before nailing. The bottom row of barrel staves should be on the inside of silo and the other rows should be on the outside. Allow one man at top to fasten top end of stave first, a man at the bottom to fasten next and a man in middle to fasten last. Pull up a crooked stave as well as can be done by hand and fasten to barrel stave, even though you have a crack one-half inch wide, as the silo hoops will close the crack to a perfect joint. When the staves are of two pieces, set up a long tongued end next to the door frame, fastening with barrel staves, as in the one-piece staves. Next to this long stave, set up short length stave with tongued end. Set up staves in this way from each side of door frame, alternating the lengths and using only staves with tongues on ends. When all tongued end staves are up, put on first and second hoops. When two hoops are on at the bottom, put up top section of frame and begin putting up long pieces with grooved ends. When all long grooved ends are in place put on two or three more hoops. Now put up short pieces with grooved ends as was done with the long grooved ends and put on all hoops. Tap top ends lightly with hammer to settle grooved ends over tongues to a tight joint. Keep inside of staves on a line marked with a nail in top foundation. When hoops are put on, staves will pull in, so that the outside staves come to this line, which makes the silo of a correct diameter. Plumb every tenth stave in and out and edgeways, and brace plumbed wall to the scaffold. Set up staves half way around from each side of door frame, putting in last stave opposite the door frame.

PAINTING TONGUE AND GROOVE.

Paint tongue and groove joints while setting up staves so that the paint will still be fresh while the staves are being fitted together.



No. 4. Process of Putting on Hoops.

PUTTING ON HOOPS.

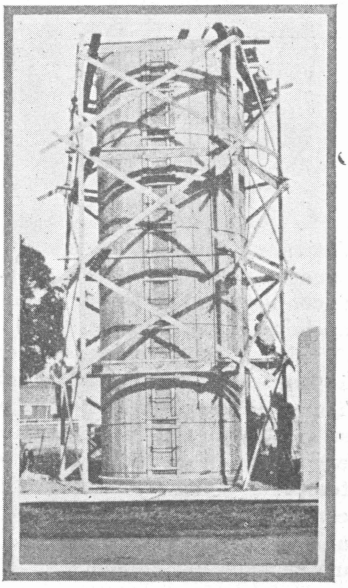
Put on second hoop from the bottom first, as shown in cut. To get hoop level around the silo, use measure from foundation to second hole in frame and with this measure, set 10D nails about one-half inch in every eight staves around the silo. Lay hoop sections on these nails and bend the nails up over the rods. Leave these nails over the hoops when the silo is finished. Put on the lug connections, so that the nut screws against the heavy end of lug. The first hoop put on will not reach around the silo without using draw rod with extra lug and nuts as a splice. When the draw-rod is in, and all the connections have been made, with each nut started so that the rod is about half way through the nut, pull up all the nuts as tightly as possible, jarring the staves into place with the pull of the hoop and watching to see that every tongue and groove fits as the staves pull together. Take off the row of barrel staves at the bottom. Put up the first and third hoops. Use a measuring stick, as long as from hole to hole in the door frame, to set the nails for all the hoops above. All of the hoops should now connect without the use of a draw-rod. Do not place the lugs in rows up and down the silo wall. Run them in a spiral, each lug about three staves to the right of the one below it. Take off the top rows of barrel staves as you approach them. When hoops are all on, see that they run about level around. This may be done by standing 200 feet from the silo. The hoop may be tapped up or down with a hammer if leveling adjustment is needed. Last, PULL ALL NUTS AS TIGHT AS IS POSSIBLE.

PUTTING ON INSIDE TOP RIM.

This rim should be a bundle of 3-8x4 inch rough sawed hardwood, shipped green, on account of its bending qualities. There should be sufficient material to make a double rim around the top of the silo. Nail on inside of silo with edge flush with the top of the silo, using 6D nails. This wood rim when dry, stiffens the silo wall and makes the top of the silo a solid ring, to which may be attached anchor pull and a plate for rafter feet.

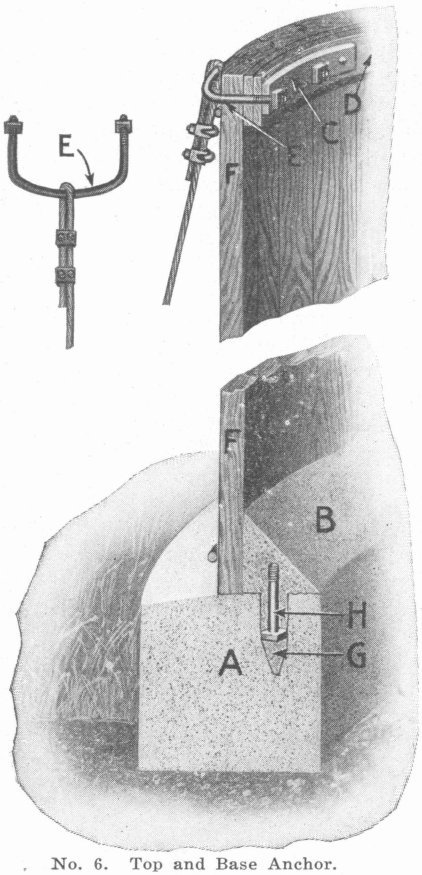
PUTTING ON ANCHORS.

Bend and fasten anchor plates on inside of



No. 5. Time to Put on Rim.

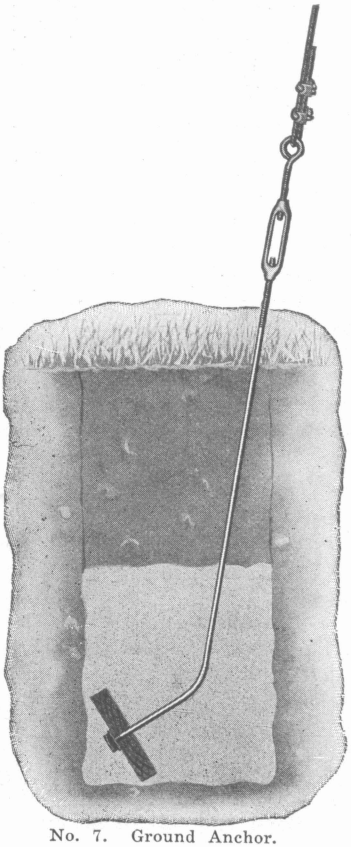
wood rim on sides of silo where you will need your anchors. With half inch bits bore through holes in anchor plates. Put "U" bolts through the holes and fasten same with nuts. Attach cable "U" bolts, using two clips to fasten cable lap. Dig holes four feet deep directly under "U" bolts and 8 feet out from silo. Put four feet anchor rods in each hole with bent end downward. Fill holes one foot deep with cement. Grout, and finish filling holes with dirt. Tamp same down thoroughly. Attach turnbuckles to threaded ends of rod in ground, screwing turnbuckles down, so that threaded end just comes through threads of turnbuckles. Screw eye in turnbuckle out, until the end of the eye threads is just through the upper end of the turnbuckle. Attach the end of the anchor cable to the eye in the turnbuckle, using two clips for each connection, as was done at the top. Tighten the turnbuckle until the cable is pulled straight and tight.



No. 6. Top and Base Anchor.

GENERAL PLANS FOR ERECTING METAL SILOS.

In erecting a metal silo, the foundation is the most important part of the silo and if properly put in, the silo is very easily and quickly erected. It is bad judgment to build a silo without protecting it with a properly built foundation. The metal sheets are set into reinforced concrete, which in turn forms the best possible anchorage protection against storms. No other anchorage is necessary.

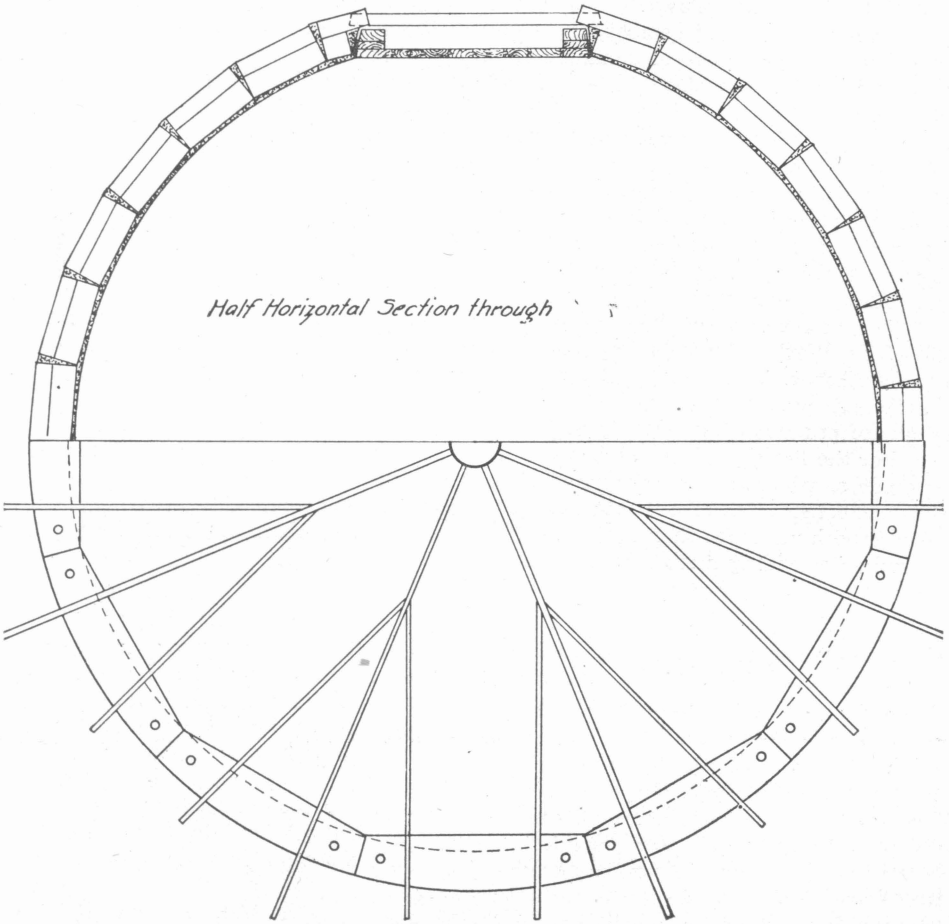

No. 7. Ground Anchor.

Mark out a circle, the diameter of which is 12 inches greater than the diameter of the silo. This will leave six inches around the walls of the silo on both the inside and outside. Make an excavation of 24 inches from top of ground to bottom of trench. This trench is for the reinforced concrete foundation on which the silo will rest and the concrete will extend 12 inches under the metal walls of the silo.

The concrete should always be reinforced to prevent cracking. Bend up one edge of the reinforcing so that it will make an upward turn in concrete under the edge of the silo. Metal silo sheets usually come in large sections—about 30 inches wide and 96 inches long. These sheets are flanged and punched at the silo factory and are bolted together in the field during erection.

Bolt two sections or rings of sheets together; afterwards set the silo section into the excavation, so that it is absolutely level. Then pour concrete and let the concrete set over night. If the section has been put in the concrete, true, round and level, the rest of the silo sheets will fit quickly and snugly, as the silo units (put out by practically all silo factories) are interchangeable.

A concrete collar, about 18 inches wide, is usually put around the interior wall of the silo and the dirt is then excavated sufficiently so there will be a slight pocket in the center for the accumulation of any excess water. This foundation, as will be seen, firmly imbeds the silo in reinforced concrete. Most metal silo factories furnish one experienced man to aid in the erection of silos.



Half Roof Framing Plan.

DIRECTIONS FOR THE CONSTRUCTION OF A HOLLOW TILE SILO.

Foundation and Floor: Where a good rock foundation is to be had reasonably close to the surface, it needs only to be leveled up with cement and the silo built upcn it. The sketch No. 8, shows a tile foundation which is recommended for firm, sandy or other soils of a like nature. For black waxy land that is inclined to crawl, an additional concrete footing four inches thick and properly reinforced, is necessary.

Begin by laying a course of tile face downward (tongue up) at right angles to the circumference of the silo. Lay these in sections of two tile, each with their adjoining ends coming right under where the center of the silo wall will be located. Directly over this course and fitting into it, lay a course of tile (tongue down—face up). Only one unit, crossing the circumference, as shown in cut is necessary for this course. The tile thus laid, should be grouted into place with concrete and mortar, proper provision being made for the placing of the floor tile, which is usually done after the walls are entirely completed. The concrete for the silo foundation should be mixed as follows:

One part Portland cement, three parts sand and five parts gravel. The cement may be of any recognized commercial brand. The sand must be clean, sharp and free from any dirt or clay. Crushed rock, that will pass through a 1 1-2 inch screen. may be used instead of gravel. The sand and cement should be mixed together first in dry form, and turned thoroughly twice; then the gravel or stone should be added dry, and the whole mass turned again. The mixture is then ready for water, which should be added until the entire mass is thoroughly wet; it should be turned until it is so completely mixed that the cement is fully distributed throughout the mass. After the concrete has become sufficiently hard for the work to proceed, the first course of the wall should be laid. This will consist of starter slabs, as shown in the following sketch:

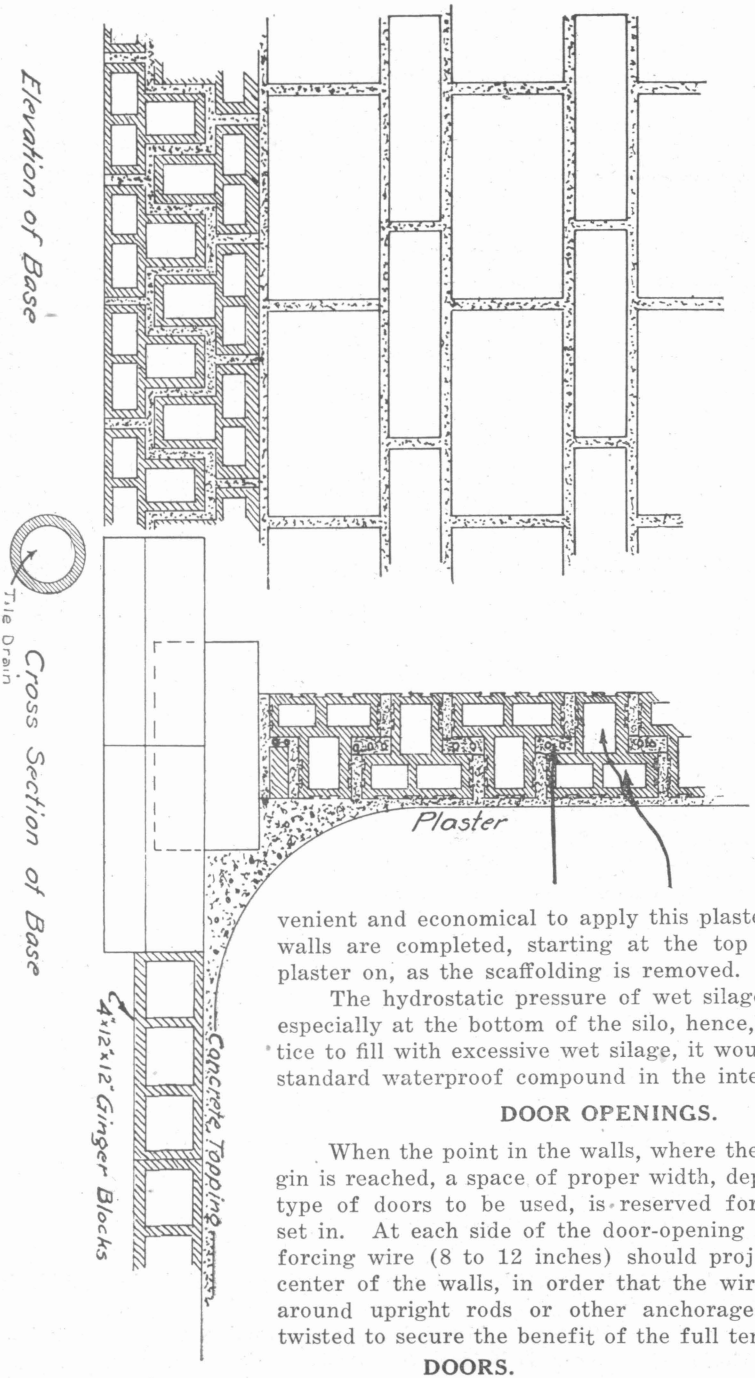
The first course of starters should make a perfect circle and the diameter of the circle should be whatever is necessary to permit the use standard interlocking tile lengths, with the inside edges touching. This will not be difficult, however, as a sufficient quantity of tile cut into four inch and eight inch lengths, can be had to eliminate practically all cutting of tile to fit small spaces.

For the floor, level up the bottom of the excavation with a cushion either of sand or cinders, whichever is cheaper and most convenient to secure. The floor shown above, is constructed of 4x12x12 hollow tile, laid flat and as close together as possible, covered with not more than an inch surfacing of cement, which binds the tile together as well as providing a smooth surface.

WALLS.

Having completed the foundation base, everything is now ready for the construction of the silo walls, the course starters having already been placed as previously explained. The tile should be laid in a mortar, composed of one part Portland cement to three parts clean sharp sand. The horizontal mortar joints should be 1-2 inch thick. The ends of the tile are always to be put against each other on the inside of the silo. The outside edges will be spread more or less, depending on the diameter. This "V-shaped" space should be thoroughly filled with mortar to within an inch or two of the inside edge, in order to make these vertical joints tight. Careless workmanship here should be guarded against, since the temptation to slight these joints is strong.

Use the level and the plumb line frequently to keep the walls going straight and true. The diagram on page 13, will show what reinforcing should go arcund each course of tile that is to be reinforced. It should be put in place before the mortar is spread, so that it can be imbeded in the mortar and thus be preserved from rust.



The ends of the reinforcing wire, should be thoroughly twisted or wrapped together after being drawn tight. Around the doors they should be looped to upright jam-rods and twisted around themselves. The interior of the silo must be finished up with a coat of cement plaster, sufficiently thick to smooth up the wall. This plaster is made by mixing together one part cement to three parts clean sharp sand, and enough water to make it of the proper working consistency. It is usually most convenient and economical to apply this plaster coat, after the walls are completed, starting at the top and putting the plaster on, as the scaffolding is removed.

The hydrostatic pressure of wet silage is considerable, especially at the bottom of the silo, hence, if it is the practice to fill with excessive wet silage, it would be well to use standard waterproof compound in the interior plaster.

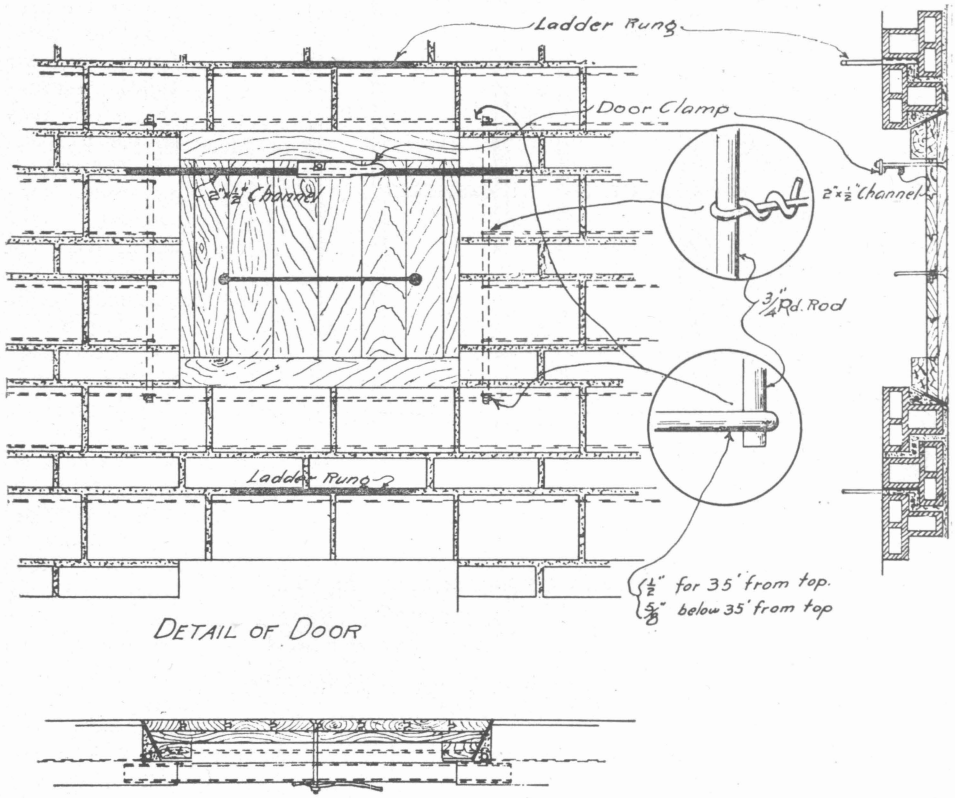
DOOR OPENINGS.

When the point in the walls, where the doors are to begin is reached, a space of proper width, depending upon the type of doors to be used, is reserved for the door to be set in. At each side of the door-opening a length of reinforcing wire (8 to 12 inches) should project out from the center of the walls, in order that the wire may be looped around upright rods or other anchorage and thoroughly twisted to secure the benefit of the full tension of the wire.

DOORS.

The selection of doors for silos is largely a matter of personal preference. The

door shown in the cut No. 13 in detail, is simply cheaply and easily made from materials which may be quickly procured from local lumber yards. Its use requires a special jamb block and more complicated construction around the doors.



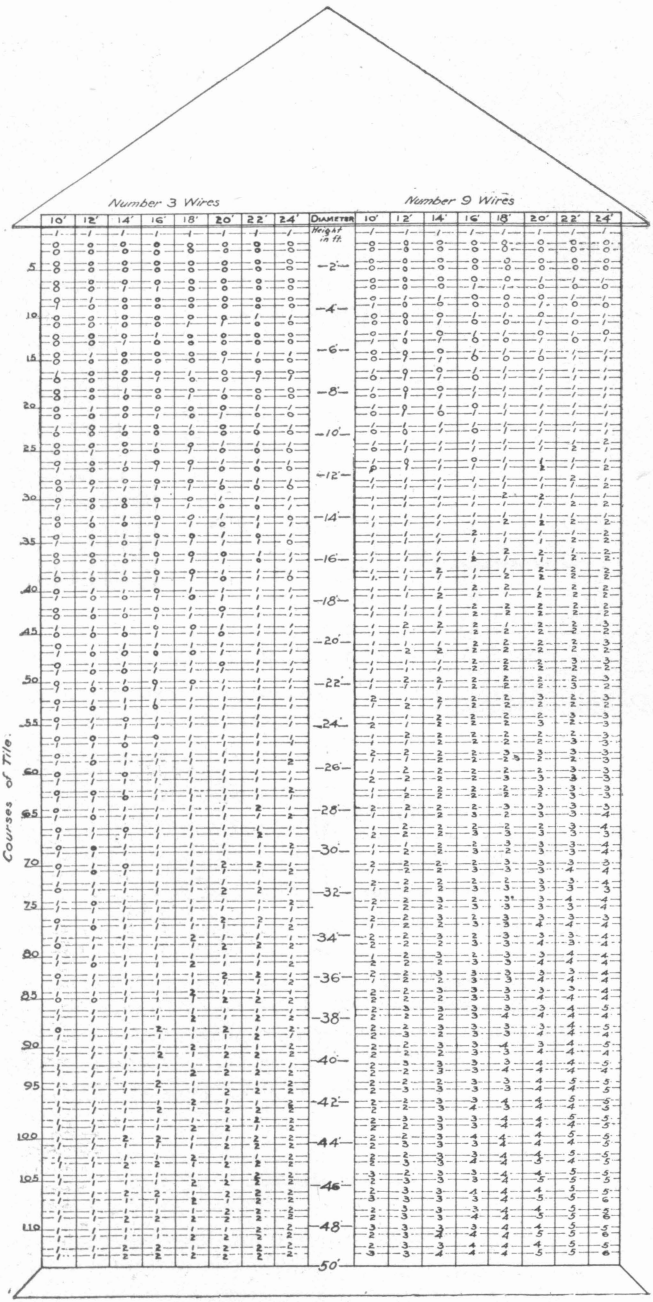
DETAIL OF DOOR

No. 10. Detail Door for Hollow Tile Silo.

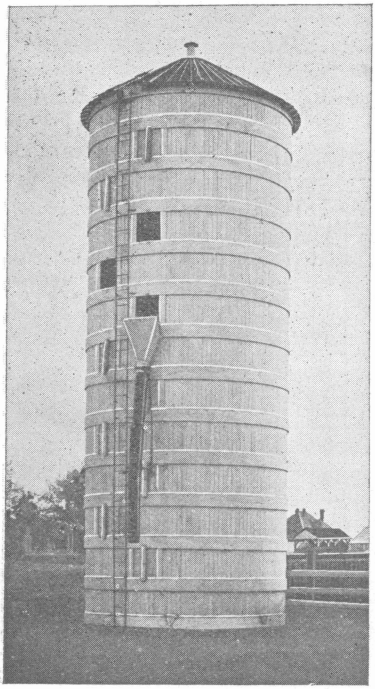
A permanent, and practically an everlasting door is strongly recommended for the hollow tile silo and it has been found that a first-class metal door, either steel or galvanized iron, can be fitted into a tile wall at low cost and will, in the long run, prove much more economical than a door that has to be renewed every few years. The additional cost of the door is largely, if not entirely made up (even in first cost) by the saving in erection expense of the tile walls, since no special jambs have to be constructed. Metal doors also provide a stiff, rigid anchorage to which to tie and twist the reinforcing wires.

LADDERS.

Ladder rungs, where needed, may be easily procured from local dealers or blacksmiths and are set into the tile wall between courses of tile at convenient distances so as to provide safe and easy climbing. Metal doors, when used, usually have fittings on them that are designed to serve as ladder steps, thus making few, if any regular ladder rungs necessary.



No. 11. Reinforcement Table.

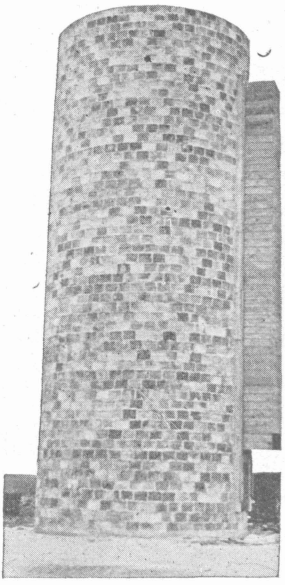


No. 12. Convenient Chute for Loading Silage Into Wagons.

CHUTE.

Every silo should have a chute to prevent the wind blowing and wasting the silage as well as for the protection against cold and rains. A chute may be built of either tile, wood, or galvanized iron and attached to fit over the doors. (See cut No. 12).

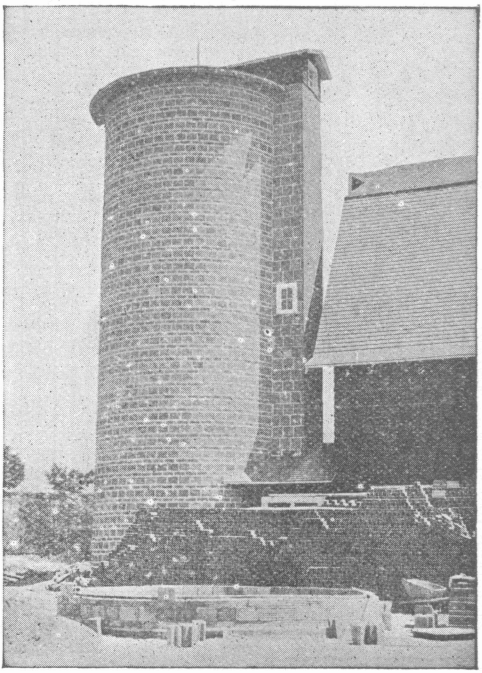
Cut No. 13 shows a tile silo 16x42 at the Keaton Dairy, Temple, Texas, built, in 1911, of common hard burned block 5x8x12, cut radial and curved to make the circle, making smooth wall with same thickness mortar joint, inside and out. This and many others of the same type have given perfect satisfaction and are permanent structures, with no reinforcing exposed to the weather, therefore, they are storm and fireproof.



No. 13. Tile Silo at Keaton Dairy

The construction of the silo shown by cut No. 14 is the same as that of other masonry silos. There is one size block to handle, with the exception of the half block for the door openings, set the same from foundation to top; but it should be plastering on the outside, below grade line, with water-proof plaster, the same as on the inside. Silage juices do not affect burned clay.

In constructing tile silos, when it is impossible to get vitrified non-absorbing tile, the inside should be treated by applying coal tar with a brush. This will also protect mortar cement from ill effects of silage juices. Treating the inside mortar joints of any masonry silo with tar, will be found well worth while.



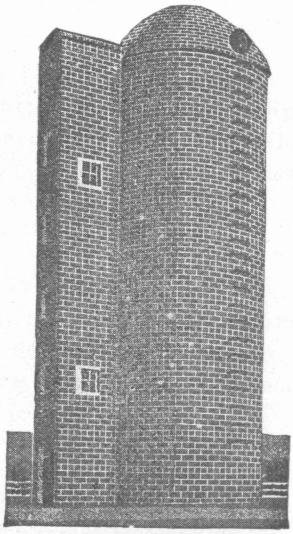
No. 14. Complete Tile Silo.

BRICK SILO.

The brick silo shown in cut No. 15 was erected in 1917,on the State Fair grounds, at Dallas, Texas, and was placed on top of the black soil, with 12 inch reinforced footing. Although the ground is flat and rather marshy, after big rains, this silo is in perfect condition and does not show any signs of cracking.

Fifty-seven hundred common brick were used in the construction of this silo, exclusive of the chute (which may be built of wood at a very low cost).

Brick silos have given excellent satisfaction, as they are not affected by storms or fire and the material can be secured from any lumber yard. If properly constructed, they are substantial and satisfactory. The comparative cost, however, is excessive, on account of the cost of the labor in its erection.



No. 15. Brick Silo.

FOUNDATION.

A brick silo can be laid on clay or rock, if it does not require an excavation of more than 3 feet. A 13 inch footing wall should be built 12 inches high around the entire circle. On the center of this wall, a 9-inch wall should be started with a header course and fiinished with a header course at the grade line, using a No. 6 wire in each mortar joint of this foundation. If a steel door frame is used, the 9-inch wall and foundation should be made a true circle, or if a flat wooden door is used, allow that portion of the wall, directly below the door opening and for 9 inches on each side of the door, to be flat. This section, which is 3 feet 6 inches wide, should be flat from the foundation to the top of the silo. If not on a solid foundation, use 12x12 concrete foundation, carrying three 5-8 inch twisted steel bars for reinforcing.

WALLS.

On the header course previously noted, an 8 inch wall should be started and carried up 20 feet, with a header course every sixth course and finished with a row lock course. The door opening should be started about 4 feet from the bottom of the silo, which should be below the ground, if excavated for foundation. On the row lock course, the 4 inch wall should be started flush with inside of an 8 inch wall and continued to the top. If the silo is less than 16x40 feet, no 8 inch wall is necessary, but same may be 4 inch wall from the bottom.

DOORS.

If steel doors and door frames are used, all the wall should be a true circle and the labor saved and the perfect fit of door will more than compensate for such cost, however, a very satisfactory frame for wooden doors can be made of angle iron, or concrete, by using a proper form.

PLASTERING.

The walls should be plastered on inside with a water proofed plastering, applied according to manufacturer's directions.

MORTAR.

The mortar should be one part best Portland cement and three parts good, clean, sharp sand, made up with lime water, carrying barely enough lime to make it set up.

REINFORCING.

A No. 6 wire should be laid in each third mortar joint for 15 feet, then use less wire gradually from there to the top; 3-8-inch bolts, 6 1-2 inches long, should be placed every 6 feet on each side of the door openings and 3 1-2 feet apart for hanging the chute.

SCAFFOLD.

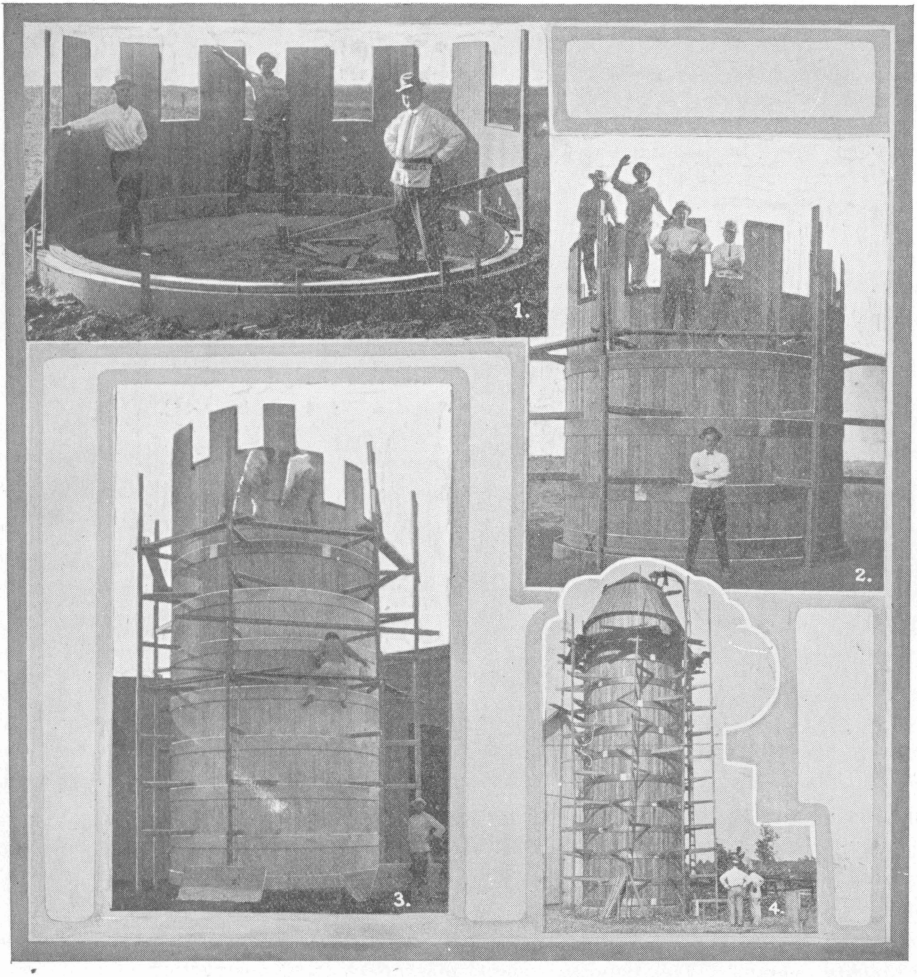
The scaffold is all on the inside and is the same as that in other masonry silos, requiring very little lumber. It is easily hoisted and lowered with blocks. Any experienced erector can build the scaffold in one day and it is easily taken down and may be hauled on one wagon.

WOODEN SILOS OTHER THAN STAVE.

For use in Texas, experience indicates that only red wood, fir, or cypress will give satisfactory long-time service, when used in the manufacture of silos. Red wood and fir silos are available in the common stave types, but cypress lumber has become too valuable to justify the using of long length staves. A very satisfactory type of cypress silo has been developed, however, by using short lengths of cypress, built into sections at the factory. These are built as shown in the accompanying cuts, into a rigid building, by making the walls of inter-locking sections, banded with hoops of some durable wood-like cypress. Where heart cypress is used in the making of these sections, the silos will last a long time. The makers of this type, claim in its favor that cypress is durable and the form is easily constructed, and that the stationary wooden hoops remain tight.

The same sort of a foundation is recommended for all wooden silos, the fundamentals of which are discussed on preceeding pages.

At times conditions may arise which will justify the use of a cheap, or flimsy type of a homemade silo, made of ordinary lumber. Such silos should be regarded, however, as only for temporary use, to bridge over an emergency arising from a temporary necessity for a larger tonnage than the regular system of farming would ordinarily demand. This condition sometimes arises from destruction of grain crops by drought, or the damaging of hay and fodder crops by excessive rains.



No. 16. The above cut shows the construction of a popular make of wooden silo manufactured in sections which is easily erected.